This leads us to notice the Watt Room, or attic workshop of James Watt, which still remains at Heathfield Hall precisely as he left it—his lathe and bench standing at the window, his tools lying about, and his old leather apron hung on the vice. There are numerous shelves with drugs and parcels on them, chiefly relating to his invention of copying-ink, and nests of small drawers full of tools; but the principal objects which strike the attention are two large machines for copying sculpture, whether in marble, alabaster, or wood. One of them copies to the exact size of the original, but the other is a reducing machine, taking a copy on a very reduced scale. The construction of both machines is described in the paper, and bears testimony to the inventive and mechanical genius of James Watt. The principle in each case consists in using a bar or slide, having at one end a blunt point to feel over the surface of the model, and at the other end a quick-running drill to cut away the surface of the material operated on. This drill is worked by a light cord attached to an ordinary foot lathe, whilst the bar, by means of a skilful arrangement of trussed frames, is made movable in any direction as the feeler passes over the model. The model and work can also be rotated, so as to be set at an angle for handcutting, &c. The drills and cutters, of which a large number are preserved, are excellent in their design and workmanship. These machines were apparently the amusement of Watt's late years, and are frequently referred to in his correspondence. They were never protected in any way, and partly perhaps for that reason have never been followed up and brought to perfection.

The second paper read was a report by the Research Committee on Friction. The Institution experiments on friction, which have been long delayed, have at length been carried so far as to admit of the publication of an interim report, prepared by Mr. Beauchamp Tower, which proves to be of great interest. They are, properly speaking, experiments on *lubrication*, being conducted on a 6-inch steel shaft or journal, which could be run at any given velocity, and on which rested a brass bearing carrying a loaded frame. By altering the load on this frame the pressure per square inch on the brass could be altered; and the temperature could also be altered by means of gas jets under the journal. As a standard of comparison experiments were first tried with the underside of the journal running in a bath of oil, so as to give the maximum of lubrication. The results of these experiments were to show that the friction of bearings under such circumstances follows the laws of liquid rather than (as usually assumed) of solid friction. These laws are very different. Solid friction varies directly as the pressure per unit of area, is independent of velocity at low speeds (Morin), but decreases with increasing velocity at high speeds (Galton, &c.). Liquid friction, on the other hand, is independent of the pressure per unit of surface, is directly dependent on the extent of surface, and increases as the square of the velocity. In fact it is not friction at all, but the shearing of one part of a more or less viscous fluid across another, as the above law plainly indicate. Now the Institution experiments show that, in the case of oil-bath lubrication, there is really a film of liquid oil surrounding the journal and keeping it away from the brass; and that what is called journal friction is really the shearing of one part of this film over the other. In such cases the friction may be exceedingly small: in some of these experiments it actually was as low as 1/1000th, and 1/500th is easily attained. This is much below what is generally supposed to obtain. The limit of pressure appeared to be about 600 lbs. per square inch. Beyond this the oil is squeezed out, and the metal "seizes." This is of course with high speed and constant pressure; with low speeds and intermittent pressure (as was pointed out in the discussion) very much higher pressures are admissible.

So far the experiments were satisfactory; but when the oil-bath was replaced by ordinary modes of lubrication, great difficulties were experienced. When the oil was introduced from above through grooves in the brass, it was found that, however these were cut, and at whatever part of the brass then opened, the bearing seized at a comparatively low pressure. The fact that such methods do as a matter of fact answer with ordinary railway vehicles is accounted for, it is supposed, by the end play of such bearings, and probably also by the general vibration. When, however, a pad fed with oil by capillary attraction from a bath below, was placed below the journal, so as to press lightly against it, satisfactory results were obtained, although the lubrication was so slight as only to appear to the touch as a slight greasiness. The laws here, however, approximated to those of solid friction, and probably the oil merely acts to fill up the little inequalities of the metal, and so practically render it smoother.

A curious subsidiary result should be noticed. When the oil-bath experiments were in progress, advantage was taken of the brass being removed to drill a hole in it for the subsequent tests with ordinary lubrication. On resuming the running, however, the oil was found in the hole, and on a pressure-gauge being attached, the finger rose to above 200 lbs. per square inch, which was the limit of its indications. This pressure was above the *average* pressure on the brass, and shows clearly that the surfaces are separated by a continuous film of oil, having at each point an actual hydrostatic pressure due to the external pressure which obtains at that point.

On the whole, these experiments, while to a great extent confirming the well-known researches of Prof. Thurston in America, throw a good deal more light on the curious phenomena and laws of journal friction. Their results (including some on temperature, which was found to have a marked influence in diminishing friction) are contained in a series of tables, which our space forbids us to publish, but which can no doubt be obtained, by any one interested, from the offices of the Institution, at 16, Victoria Chambers, Westminster.

NORDENSKJÖLD'S GREENLAND EXPEDITION[1]

II.

IN my report of the expedition of 1870 I drew attention to a clayey mud which is found in circular cavities, from one to three feet in depth, on the surface of the inland ice, not only near the shore, but even as far inland as we reached on that occasion. My companion on that occasion, Prof. Berggren, discovered that this substance formed the substratum of a peculiar[2] ice-flora, consisting of a quantity of different microscopical plants (algæ), of which some are even distributed beyond the clay on the ice itself, and which, in spite of their insignificance, play beyond doubt a very important part in nature's economy, from the fact that their dark colour far more readily absorbs the sun's heat than the bluish-white ice, and thereby they contribute to the destruction of the ice-sheet, and prevent its extension. Undoubtedly we have, in no small degree, to thank these organisms for the melting away of the layer of ice which once covered the Scandinavian peninsula. I examined the appearance of this substance in its relation to geology, and demonstrated:—

1. That it cannot have been washed down from the mountain ridges at the sides of the glaciers, as it was found evenly distributed at a far higher elevation than

[1] Continued from p. 13.

[2] Lately described by Prof. V. Wittrock. "Om Snöns och Isens Flora, Särskildt i Arktiska Trakterna." Ur "A. E. Nordenskjöld, Studier och Forskningar föranledda af mina resor i höga Norden." (Stockholm, 1883.) See NATURE, vol. xxviii. p. 304.

that of the ridges on the border of the glaciers, as well as in equal quantity on the top of the ice-knolls as on their sides or in the hollows between them.

2. That neither had it been distributed over the surface of the ice by running water, nor been pressed up from the hypothetical bottom "ground" moraine.

3. That the clay must therefore be a sediment from the air, the chief constituent of which is probably terrestrial dust spread by the wind over the surface of the ice.

4. That cosmic elements exist in this substance, as it contained molecules of metallic iron which could be drawn out by the magnet, and which under the blowpipe gave a reaction of cobalt and nickel.

Under these circumstances the remarkable dust which I have named "kryokonite," *i.e.* ice dust, obtained a great scientific interest, particularly as the cosmic element, viz. the matter deposited from space, was very considerable. Even later students who have visited the inland ice have observed this dust, but in places surrounded by mountains from which it might with more probability have been washed down. They have, therefore, and without having examined Prof. Berggren's and my own researches of 1870, paid little attention to the same, while the samples brought home by Dr. N. O. Holst from South Greenland in 1880 were not very extensive.

But now Dr. Berlin brings home from a great variety of places ice algæ, which, I feel convinced, will contribute fresh materials to our knowledge of the flora of the ice and snow. For my own part I have re-examined my first researches of the kryokonite, and they are fully corroborated. Everywhere where the snow from last winter has melted away, a fine dust, gray in colour, and, when wet, black or dark brown, is distributed over the inland ice in a layer which I should estimate at from 0·1 to 1 mm. in thickness if it was evenly distributed over the entire surface of the ice. It appears in the same quantity in the vicinity of the ice border surrounded by mountains as a hundred kilometres inland, but in the former locality it is mixed with a very fine sand, gray in colour, which may be separated from the kryokonite. Further inland this disappears, however, completely. Gravel or real sand I have never, in spite of searching for them, discovered in the kryokonite. The kryokonite always contains very fine granular atoms, which are attracted by the magnet, and which, as may be demonstrated by grating in an agate mortar and by analysis under the blowpipe, consist of a gray, metallic element, viz. nickel iron. In general the dust is spread equally over the entire surface of the ice; thus it was found everywhere where the snow from the previous year had melted away, while, to judge by appearances, there seemed to be little difference between the quantity found near the coast and in the interior. The dust does not, however, form a continuous layer of clay, but has, by the melting of the ice, collected in cavities filled with water, which are found all over the surface. These are round, sometimes semicircular, one to three feet in depth, with a diameter of from a couple of millimetres to one metre or more. At the bottom a layer of kryokonite one to four millimetres in thickness is deposited, which has often, by organisms and by the wind, been formed into little balls, and everywhere where the original surface of the ice has not been changed by water-currents the cavities are found so close to each other that it would be very difficult to find a spot on the ice as large as the crown of a hat free from them. In the night, at a few degrees below freezing point, new ice forms on these hollows, but they do not freeze to the bottom even under the severest frost, and the sheet which covers them is never strong enough to support a man, more particularly if the hole is, as was the case during half our journey, covered with a few inches of newly-fallen snow.

The kryokonite cavities were perhaps more dangerous to our expedition than anything else we were exposed to. We passed, of course, a number of crevasses without bottom as far as the eye could penetrate, and wide enough to swallow up a man, but they were "open," *i.e.* free from a cover of snow, and could with proper caution be avoided, and the danger of these could further be minimised by the sending of the two-men sledges in front, and if one of the men fell into the crevasse he was supported by the runners and the alpenstock, which always enabled him to get up on the ice again. But this was far from being the case with the kryokonite hollows. These lie, with a diameter just large enough to hold the foot, as close to one another as the stumps of the trees in a felled forest, and it was therefore impossible not to stumble into them at every moment, which was the more annoying as it happened just when the foot was stretched for a step forward, and the traveller was precipitated to the ground, with his foot fastened in a hole three feet in depth. The worst part of our journey was four days outward and three days of the return, and it is not too much to say that each one of us during these seven days fell a hundred times into these cavities, viz. for all of us 7000 times. I am only surprised that no bones were broken, an accident which would not only have brought my exploration to an abrupt close, but might have had the most disastrous consequences, as it would have been utterly impossible to have carried a man in that state back to the coast. One advantage the kryokonite cavities had, however, viz. of offering us the purest drinking-water imaginable, of which we fully availed ourselves without the least bad consequences, in spite of our perspiring state.

On July 16 we covered thirteen, on the 17th eighteen and a half, and on the 18th seventeen and a half kilometres. The country, or more correctly the ice, now gradually rose from 965 to 1213 metres. The distances enumerated show that the ice became more smooth; but the road was still impeded by the kryokonite cavities, whereas the rivers, which even here were rich in water, became shallower, but stronger, thus easier of crossing. Our road was, besides, often cut off by immense snow-covered crevasses, which, however, did not cause much trouble.

On the night of the 18th, when arrived at camp No. 14, the Lapp Anders came to me and asked if he might be permitted to "have a run," viz. to make a reconnaissance on "skidor,"[1] to see if there was no "land" to the east. This granted, he started off without awaiting supper. He came back after six hours' absence, and reported that he had reached 27 kilometres further east, that the ice became smoother, but was still rising, but there was no sign of "land." If his statement was true, he had, after a laborious day's journey, in six hours covered about sixty kilometres! At first I considered his estimate exaggerated, but it proved to be perfectly correct. It took us thus *two whole* days to reach as far as he had got, as shown by the track in the snow. I particularly mention this occurrence in order to show that the Lapps really did cover the estimated distance of their journey eastward, of which more below.

During these days we passed several lakes, some of which had the appearance of not flowing away in the winter, as we found here large ice blocks several feet in diameter, screwed up on the shore, which circumstance I could only explain by assuming that a large quantity of water still remained here when the pools about became covered with new ice. The lakes are mostly circular, and their shores formed a snow "bog" which was almost impassable with the heavy sledges.

On July 19 we covered seventeen and a half, on the 20th sixteen and a half, on the 21st, seven, and on the 22nd seven and a half kilometres (15th to 18th camp). The ice rose between them from 1213 to 1492

[1] [The Swedish "skidor" and Norwegian "Ski," are long strips of pine-wood slightly bent at the top, polished and as elastic as if they were of the finest steel, with a strap for the feet in the centre, on which the Lapps and Scandinavians run on the snow with remarkable agility at a tremendous pace.—Ed.]

metres. The distances enumerated fully show the nature of the ice. It was at first excellent, particularly in the morning, when the new snow was covered with a layer of hard ice; but on the latter days we had great difficulty in proceeding, as a sleet fell with a south-east wind in the night between the 20th and the 21st. The new snow, as well as that lying from the previous year, became a perfect snow bog in which the sledges constantly stuck so that it required at times four men to get them out. We all got wet, and had great difficulty in finding a spot on the ice dry enough to pitch the tent. On the 22nd we had to pitch it in the wet snow, where the feet immediately became saturated on putting them outside the indiarubber mattresses. A little later on in the year, when the surface of the snow is again covered with ice, or earlier, before the thaw sets in, the surface would no doubt be excellent to journey on.

When we, therefore, on July 21, were compelled to pitch the tent in wet snow, as no dry spot could be discovered, and it was impossible to drag the sledges further, I sent the Lapp Lars Tuorda forward on "skidor" to find a dry road. He came back and stated that the ice everywhere was covered with water and snow. For the first time in his life he was at a loss what to suggest. It being utterly impossible to get the sledges further, I had no choice. I decided to turn back.

I wished, however, to let the Lapps go forward some distance to the east to see the country as far as possible. At first I considered it advisable to let their journey only last twenty-four hours, but as both Anders and Lars insisted that they were most eager to find the "Promised Land," and said they could do nothing towards discovering it in that short period, I granted them leave to run eastwards for four days and nights, and then return.

On leaving I gave them the following written orders :—

"Instructions for Lars and Anders's 'skid' run on the inland ice of Greenland, viz. :—

"Lars and Anders have orders to proceed on skidor eastwards, but are allowed to alter the course, if they may deem it advisable, to north or south.

"At the end of every third mile the barometer shall be read and the direction run noted.

"The absence is to be four days, but we will wait for six days. After that, viz. on the morning of July 28, we return. If not returned, we leave behind in a sledge provisions, brandy, mattresses, &c.

"Lars is warned not to be too bold. Should land be reached, you are to collect as much as you may gather of blossoms and grass, if possible several kinds (specimens) of each.

"Given on the inland ice in Greenland, July 21, 1883,

"A. E. NORDENSKJÖLD"

They were allowed to select what provisions, &c., they desired, and were furnished with two compasses, aneroid barometers, and a watch.

At 2.30 a.m. on July 22 they started. The days we waited for them were generally spent in the tent, as water surrounded us everywhere. The sky was covered with a thin veil of clouds, through which the sun shone warmly, at times even scorchingly. From time to time this veil of clouds, or haze, descended to the surface of the ice and hid the view over the expanse, but it was, remarkably enough, not wet but *dry*, yes, so dry that our wet clothes absolutely dried in it. We have therefore, I consider, witnessed a phenomenon on the inland ice of Greenland which is related to the "sun-smoke" phenomenon of Scandinavia, viz. what Arago has described under the name "brouillard sec."

On the 24th, after an absence of fifty-seven hours, the Lapps returned. It was the want of drinking-water and fuel which compelled them to return. The surface had been excellent for their journey, and they had covered a distance out and back of 230 kilometres, an estimate which I consider perfectly reliable. During the march forward the barometer was read every third hour. It gave the point of return a height of 2000 metres.[1]

As to the run, Lars rendered the following report: When they had reached thirty miles from the camp no more water could be found. Further on the ice became perfectly smooth. The thermometer registered $-5°$ C. It was very easy to proceed on the "skidor." At the point of return the snow was level and packed by the wind. There was no trace of land. They only saw before them a smooth ice covered by fine and hard snow. The composition of the surface was this—first four feet of loose snow, then granular ice, and at last an open space large enough to hold an outstretched hand. It was surrounded by angular bits of ice (crystals). The inland ice was formed in terraces—thus, first a hill, then a level, again another hill, and so on. The Lapps had slept for four hours, from twelve midnight on July 23, in a hollow dug in the snow while a terrific storm blew. They had till then been awake for fifty-three hours. On the first day there was no wind, but next day it came from the south, and lasted thus until twenty-four miles on the return journey, when it changed to west. On the return journey, when forty miles from our camp, two ravens were seen. They came from the north and returned in the same direction. The Lapps had for a moment lost the track of the "skidor" in the snow. The ravens flew at first, they found, parallel with the track, and then turned to the north.

On July 25 we began the return journey. It was high time, as the weather now became very bad, and it was with great difficulty we proceeded in the hazy air between the number of crevasses. The cold, after the sun sunk below the horizon at night, also became very great; and on the morning of July 27 the glass fell to $-11°$ C.

As to the return journey I may be very brief. The rivers now impeded us but little, as they were to a great extent dried up. The ice-knolls had decreased considerably in size too, and lay more apart, but the glacial crevasses had greatly expanded, and were more dangerous, being covered with snow. Even the cavities and the glacial wells, of which many undoubtedly leave a veritable testimony of their existence behind them in the shape of corresponding hollows in the rock beneath, had expanded and increased in number. On a few occasions, on the return journey, we saw flocks of birds, most probably water-fowl, which were returning from the north.

On July 31 we again sighted land, which was reached on the afternoon of August 4, and proceeded to "Sophia Harbour," where Esquimaux were, as arranged, waiting for us. For convenience sake I now divided our party into two, one of which sailed in the lifeboat of the *Sophia* to Egedesminde, where the steamer was to take us on board, and the other, in which was myself, marched to that place across the low but broad promontory which separates Tessiusarsoak and South-East Bay, and then in two Esquimaux "Kone" boats to Ikamiut and Egedesminde.

On August 16 the *Sophia* arrived from the north, embarked us, and made for Ivigtut, where we arrived on the 19th.

Of the expedition carried out under Dr. Nathorst during my absence he will himself make a report,[2] and I have no doubt that the results of the same will prove very important. Particularly will the very rich collections of fossil plants, which he has made with the greatest regard to the geological condition of the strata, be of great value to science, as they will furnish us with many new materials and detailed illustrations of the flora of the Far North during the epoch when forests of fig-trees, cycadi, ginko, magnolia, and tulip-trees covered these regions. Dr. Forsstrand and Herr

[1] I have as yet been unable to verify the barometer calculations and the figures stated here may suffer some modification.

[2] NATURE, vol. xxviii. p. 541.

Kolthoff's collections and studies of the fauna of Greenland will also contribute to extend our knowledge of the naturalistic conditions of the Arctic regions, while the careful researches made by Herr Hamberg of the saltness, composition, and temperature of the sea will, I am sure, greatly benefit hydrography. His researches have been effected in Davis Strait and Baffin's Bay too, the hydrographical conditions of which are but little known.

With regard to the results of my exploration of the inland ice, I may be permitted to say a few words. That we found no ice-free land in the interior, or, that it does not exist between 68° and 69° lat. in Greenland, is due directly to the orographical conditions which exist in this part of the country, as referred to in my programme of the expedition.[1] The land has here the form of a round loaf of bread, with sides which gradually and symmetrically slope down to the sea, *i.e.* exactly the shape which I then pointed out was a necessary condition if the entire country should be covered with a continuous sheet of ice.

But, thanks to the Lapps, my expedition is the first which has penetrated into the very heart of the enormous Greenland continent, and which has thus solved a problem of the greatest geographical and scientific importance. It is the first exploration of the hitherto unknown interior of Greenland, the only continent in the world into which man had not penetrated.

A new means of locomotion, the "skidor," seems also to have been acquired for the Arctic explorer of the future, which may greatly assist him in his work, and enable him to reach places hitherto deemed impossible of approach, but of the use of which the Lapp seems to possess, so to speak, the monopoly.

A. E. NORDENSKJÖLD

We are enabled to supplement Baron Nordenskjöld's report by the following account, furnished to us by another member of the expedition, of the visit paid to the remarkable Igaliko ruins :—

On August 24 the *Sophia* steamed to Igaliko, at the bottom of the fjord of the same name. The object of this visit was to examine the ancient Norse ruins which are found here. Those who thus believe that the "Österbygd" of Greenland was situated in this part assert that the ruins of Igaliko are nothing more nor less than those of Erik Röde's own mansion "Brattelid." However that may be, the Norseman who selected this spot for his residence acted very wisely. The ruins are situated at the very bottom of the fjord, where the absence or presence of the ocean ice on the coast affects the climate but little. The vegetation in this spot is, in consequence, quite luxuriant. Thus a vaginal plant, *Lathyrus maritimus*, grows here in such abundance that it reminds one of a field of peas, while *Ranunculus acris* attains a height of two feet, and *Campanula rotundifolia*, the bluebell, along with various grasses, flourish in great profusion. In the pools Menyanthes and Potamogeton thrive, while copses of birch-trees and willows offer excellent fuel. There are also plenty of wild berries. The ruins, the walls of which were formed of enormous blocks of sandstone, lie just below a table-shaped ridge of sandstone by the side of a crystal brook, copiously encircled by *Alchemilla vulgaris* and watercress. The spot is, in fact, one which would fully justify the name given to the country. At the time of our visit about a dozen cows were fed here, whose excellent milk we tasted, while in the beds around the huts of the natives swedes and potatoes grew luxuriantly, the former having attained the size of large apples. It certainly was strange to view this spot, and we naturally asked each other, what has become of the old Norsemen who once peopled it? It is impossible to believe that they were extirpated or conquered by the Esquimaux. It seems far more probable that both races have commingled, an assumption further corroborated by the strange circumstance that Esquimaux are found in this tract who have never been in contact with the Danes, but who nevertheless possess features of pure Norse character.

[1] NATURE, xol. xxviii. p. 37.

THE VIENNA INTERNATIONAL ELECTRIC EXHIBITION

(FROM OUR VIENNA CORRESPONDENT.)

THE Scientific Commission having for its purpose the taking of electrical measurements and conducting scientific researches at the Exhibition commenced its work on September 17. By the assembled Austrian and foreign delegates Prof. Stefan (Vienna) was elected president, while as vice-presidents were elected Prof. Galilei Ferraris (Turin), Col. J. Florensoff (St. Petersburg), Prof. Hauffe (Vienna), Prof. Kittler (Darmstadt), Major A. Obermayer (Vienna), Sir William Siemens (London), Prof. Mascart (Paris), Emil Effendi Lacoine (Constantinople), Prof. E. Gerard (Liége). The Commission is subdivided into the following eight sections according to the matters to be dealt with:—1. Scientific instruments. 2. Motors and general mechanics. 3. Dynamo-electric machines, electric lighting, and transmission of power. 4. Electro-chemistry. 5. Telegraphy, telephony, electric bells and clocks. 6. Signalling for railways and military purposes. 7. Electro-therapeutics. 8. Application of electricity relating to arts, industry, and technology. At the third section the measurements are carried out according to the plans devised for electric measurements by the president of the section, Prof. Kittler, and for photometric measurements by Prof. Voit (Munich). A control calibration of the instruments used in this section showed their accuracy and precision, as well as the correctness of the hypothesis that the variations of the earth's magnetism during the daily periods of measuring could not exert any important influence on the results of the measurements. When the first trials were made, some disturbances of the delicate instruments arose, the cause being that the iron building of the Rotunda was charged with electricity by the return currents of the dynamo-electric machines. But this difficulty was soon overcome by modifying the arrangements of the conducting wires, and the Commission is now hard at work trying the various electric lamps and machines. The results of these trials when finished will be published by the Commission. The series of lectures delivered at the theatre of the Exhibition is still continued, and we had occasion to hear, among others, Mr. Preece (who spoke in English), on the recent progress of telegraphy in England, and the Austrian professors Mach, Zenger, Pfaundler, Waltenhofen. The attendance on the part of the public is as large as it was at the Universal Exhibition in the year 1873, the average number of visitors being 15,000 daily.

While in the Bernstein lamps described in our last letter a relatively thick carbon is used, in the Cruto lamps brought to the Exhibition a few days ago a very fine but hollow carbon loop is employed; it is prepared by a process similar to that already devised by Mr. Sawyer in the year 1878 for flashing carbon filaments. A thin platinum wire (1/20 mm. to 1/60 mm. in diameter) is heated, by an electric current passing through it, in a vessel containing the vapour of a hydrocarbon. The hydrocarbon being decomposed in a short time, the platinum wire is covered by a homogeneous layer of deposited pure carbon. The platinum is then removed by volatilising it. The remaining hollow carbon filaments thus obtained are very fine and elastic, and show a metallic polish. The Cruto lamps, as well as a series of Lodiguine incandescent lamps, are fed by Gravier's distributers of electricity, the installation of which has been completed during the past week. The